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GEOPHYSICS.—*Geophysical measurements in the laboratory and in the field.*[1]

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It has been recorded that, in the beginning, Jehovah created the heaven and the earth. Since those early days time has wrought many changes, not only in the universe at large as we suspect it exists today, but upon this planet upon which our senses seem to indicate to us we are living and striving to preserve some kind of continuity of that life. Experience and experiments tell us that, among other things, this planet, the earth, is surrounded by an ionosphere, a stratosphere, an atmosphere, and a magnetic field. Those portions of the earth that are on or immediately below the surface are called the hydrosphere (water area) and the lithosphere (crust). Within a relatively thin film of the atmosphere, the hydrosphere, and the lithosphere, we observe the effects of forces that are continuously and relentlessly modifying the earth. The science that treats of these forces is known as geophysics, and in this field we find such sciences as geodesy, seismology, geomagnetism, meteorology, volcanology, hydrology, and techtonophysics.

This paper deals briefly with certain physical measurements in geomagnetism and in seismology, describes in some detail a few of the instruments and methods used in such measurements, and compares some of the results obtained in the laboratory with results obtained in the field with the same equipment. While these few illustrations by no means cover the whole field, either in the experiences of the author or of his immediate associates, they will serve to illustrate the complex nature of some of the projects upon which we are working—projects that involve questions of law, regulations, policy, funds, personnel, and equipment.

In the field of geomagnetism, one of our main objectives has been, and still is, the production of magnetic maps, charts, and tables, applicable to the United States and its possessions. Unfortunately it is necessary to reconstruct or revise these charts and tables at intervals of a few years simply because the earth's magnetic field is not uniform and because it is changing continuously in both direction and intensity. The magnetic meridian at a particular site is defined as the vertical plane fixed by the direction of the earth's field at that site. The true meridian at the same site is a vertical plane containing the earth's axis. The latter is determined by astronomical observations and for convenience may be marked by the establishment of a permanent monument erected at some distance from the site. It is usually more convenient to erect the mark and then determine its true azimuth.

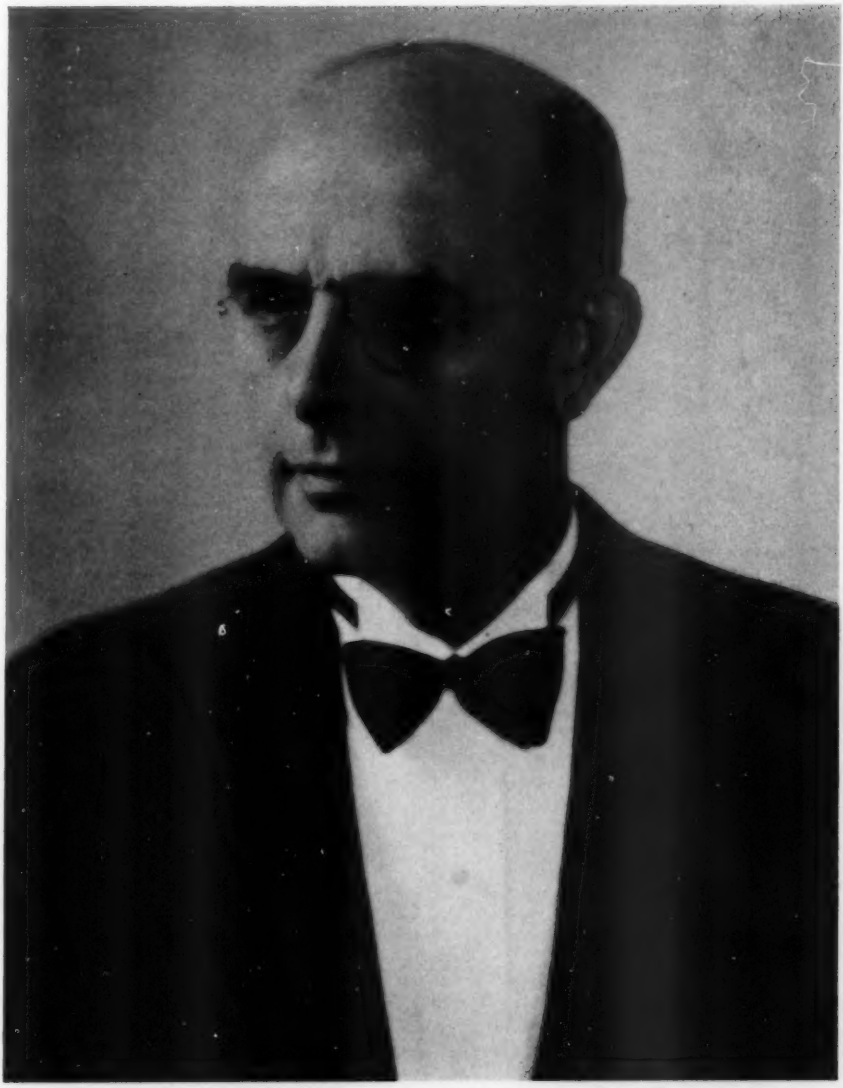
The angle between the true meridian and magnetic meridian is known as magnetic declination. The direction of the magnetic field changes as time passes, and while many of these changes are irregular and some may even be classed as violent, there is, after all, considerable regularity in these changes. At Cheltenham, Md., for example, the direction of the field has changed from N. 5° 41′ W. to N. 7° 06′ W. during the past 30 years, the average rate being about 3′ per year. This is known as secular variation or secular change. Where the rate of secular change has been fairly uniform for several years, it is reasonably safe for all

[1] Address of the retiring President of the Philosophical Society of Washington delivered at the 1194th meeting of the Society, January 17, 1942. Received February 2, 1942.

practical purposes to predict changes for a few years in advance. This rate has been diminishing for the past few years, and at present it is practically at zero at Cheltenham. In addition to this secular variation, the direction of the field normally passes through a complete cycle of change every solar day. The normal daily range in declination at Cheltenham is of the order of 4 or 5 minutes of arc. Likewise, the total field intensity varies in direction and magnitude from day to day and from year to year. All these changes vary over wide ranges for different parts of the earth. In order to make it possible to obtain continuous records of all the fluctuations, magnetic observatories have been established in various parts of the world. One of the earliest of these observatories was established at Girard College, Pennsylvania, in 1838, and was operated almost continuously with eye-reading instruments for 6 years, beginning with 1840. In 1852 the Smithsonian Institution established a magnetic observatory on the Smithsonian grounds and operated the first photographic recording instruments in this country. Since the early part of the present century the Coast and Geodetic Survey has operated observatories at five widely separated sites, ranging from southern Alaska to Puerto Rico, and from Maryland to Hawaii.

The base, the standardizing observatory, is at Cheltenham, Md. The buildings there are constructed of nonferrous materials throughout and are insulated against temperature changes. It has been found convenient to record photographically the changes in magnetic declination and the horizontal and vertical components of the field intensity. The declination variometer consists of a small magnet suspended in a damping chamber by a fine quartz fiber, which, when in proper adjustment, is free of torsion. A plane mirror attached to the magnet system permits photographic recording. For convenience, the recording distance is usually arranged so that 1 millimeter change of ordinate corresponds to a change of direction of the field of one minute of arc. The mirror is prismatic, that is, it has three aluminized surfaces, the angles being such that should the image from the central mirror move beyond the limits of the recorder at either side, a reserve image will enter the picture and prevent loss of record. The intensity instruments are not so simple. The instrument that records the changes in the horizontal component of the field is similar to the dec-

Fig. 1.—Magnetic variation observatory at Tucson. The photographic recording instruments are mounted on concrete piers within the building, which is constructed of nonmagnetic materials and the interior is well insulated against temperature changes.



H. E. McComb, retiring President of the Philosophical Society of Washington.

lination variometer, but the suspended magnet is oriented so that its axis is approximately at right angles to the field and is held in this position by the torsion of a quartz fiber. Under the assumption of certain ideal conditions, namely, that the instrument, except for the magnet, is nonmagnetic, that the rigidity modulus of quartz remains constant, that the magnetic moment of the suspended magnet does not change, that there is no relative motion between the quartz suspension and its upper and lower attachments, that the temperature remains constant, and that there are no natural or artificial mechanical vibrations disturbing the system, then and only then is the angular motion of the suspended magnet a measure of the changes in the horizontal component of the field. While all these specifications may be met and may be maintained with sufficient precision for a few hours or a few days in the laboratory, experience has shown that most of the specifications cannot or at least have not been maintained over long periods of time in the field.

The quartz fibers are relatively large, being of the order of 30 to 40 microns in diameter. In the early installations, the fibers were attached to their supports by fused shellac, but in the course of time shellac will yield and the magnet will drift away from its normal position. This difficulty has been overcome by bending the ends of the filament or by making the fibers with enlarged, pear-shaped ends, which furnish sufficient bearing surface to eliminate slipping of the fiber relative to its supports. Some of the quartz fibers used in these instruments have been under constant torsion of two or three radians for many years. There is evidence that they have suffered little if any permanent strain.

We have not yet found a bar magnet

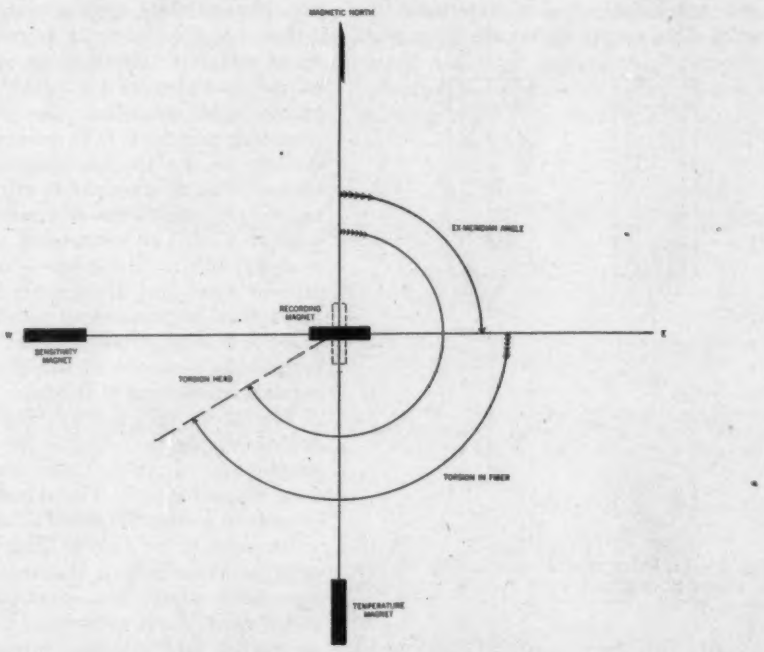


Fig. 2.—Arrangement of recording magnet and control magnets on a unifilar horizontal intensity variometer.

whose magnetic moment remains constant, and all the magnets that we have tested have temperature coefficients. Thus we find ourselves attempting to measure something that is changing continuously, with a measuring device the parts of which change in several ways while the operation is in progress. It is recognized that conditions of this kind are the rule rather than the exception in all physical measurements, even in the laboratory, but in this particular operation we are not attempting to determine the value of some constant; we are attempting

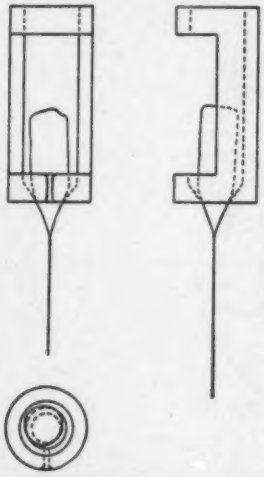


Fig. 3.—La Cour type of quartz fiber suspension showing enlarged ends resting in conical cups.

to record, with some accuracy, the changes in the horizontal component of the field. In spite of every reasonable precaution, we find that the magnetogram may be, and usually is, a record of the algebraic sum of the changes in the field intensity and changes in the instrument parts. Since both the rigidity modulus of quartz and the magnetic moment of the suspended magnet have temperature coefficients so large that they must be taken into consideration, the observatories are well insulated against sudden or large changes in temperature. In addition, the intensity instruments are compensated for temperature in a simple and effective manner.

The vertical-component instrument is simply a delicate magnetic balance. It is similar in many respects to the ordinary analytical balance, the basic difference being that the beam of the magnetic balance is a permanent magnet. The magnet is balanced against gravity on quartz or steel knife edges, and when in proper adjustment is extremely sensitive. To give some idea of the sensitivity of one of these balances it can be stated that when operating under normal conditions, a mass of 0.2 milligram, if placed at the end of the beam, would just about upset it. The moving system is, of course, provided with a suitable mirror for photographic recording. The latest type of recording magnet is that devised by Dr. D. la Cour of the Danish Meteorological Institute. The magnet, knife edges, and the mirror are made from one piece of special magnet steel. The instrument as a whole is so designed that the magnet may be operated in a vacuum. Here again is an instrument that is required to operate continuously over long periods and that is expected to provide a record of the changes in the vertical component of the field.

The three variometers that have been described, together with a suitable photographic recorder, constitute what is known as a magnetograph. The record we obtain from such a set-up is called a magnetogram.

In order to be able to analyze these records quantitatively, it is necessary to know something about the sensitivity of each component. Such measurements are made at regular intervals and consist simply of noting the deflection produced on each component by the application of a known field, properly directed.

Magnetic fields are commonly expressed in gausses, that is, lines of force per square centimeter in air. For convenience, it has been found practical in geomagnetic work to use a much smaller unit, the gamma, which is 0.00001 gauss. Also in common use is the milligauss, which is 100 gammas. The average value of horizontal component of the earth's field at Cheltenham Observatory at the present time is around 18,200 gammas. This is known as the absolute value, and at an observatory it may be determined

easily and quickly with a sine galvanometer to an accuracy of perhaps one gamma. If the absolute value is determined at the moment when the H curve of a magnetogram coincides with an arbitrary base line, then we may assign that absolute value to the base line. Once we have determined the base line value, it is a simple matter to scale the absolute value for any particular moment or to scale the average value for any interval.

Unfortunately there is only one sine galvanometer in the United States suitable for measuring H to an accuracy of one gamma. Except for the electromagnetic method, the only other known method of determining the absolute value of H is by means of a magnetometer. Experience has shown that, under most favorable conditions, the results obtained with magnetometers may be expected to be in error by as much as 5 to 10 gammas.

There are no electromagnetic instruments in the United States suitable for making a direct measurement of the absolute value of the vertical component to an accuracy comparable with that which can be attained with the sine galvanometer. The usual method and one by no means satisfactory is to measure the angle of inclination of the field and from this value and the known value of the horizontal component derive a value of the vertical component. At an observatory a single value of dip can be determined by means of an earth inductor to an accuracy of perhaps one-half minute of arc. In latitude 40° N. an uncertainty of 0.5′ in inclination gives an uncertainty of about 50 gammas in the derived value of the vertical intensity. In practice the uncertainty is much less, since average values are used.

From all this it should be apparent that, even though observatory values may be given to gammas, the uncertainty in the absolute values may be much greater. However, in spite of the fact that there may be considerable uncertainty in the absolute values of some of the elements, the magnetograph furnishes an excellent continuous record of the changes in these elements to a surprisingly high degree of accuracy. This

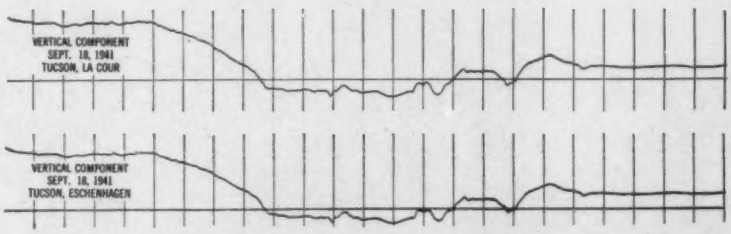


Fig. 4.—Magnetograms recorded by two types of vertical intensity variometers operating simultaneously in different observatories at Tucson. The new observatory, in which the la Cour instrument operates, is partly underground. The vertical lines are hour-marks, the first being at 8.00 a.m., local standard time.

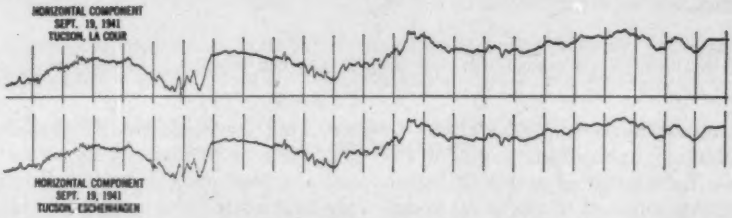


Fig. 5.—Magnetograms as recorded by two types of horizontal intensity variometers under conditions similar to those described under Fig. 4.

is fortunate, since in recent years there has been considerable demand for immediate and fairly complete information concerning the so-called magnetic character of the day and its shorter intervals. Data of this kind are supplied daily to investigators in radio transmission. The time may not be far distant when through cooperative efforts of many agencies it may be possible to make fairly reliable forecasts of the quality of radio reception to be expected.

Let us now consider what happens when we attempt to make a magnetic survey of large areas such as the United States. Obviously, the first step is to make a great many observations, well distributed over the whole area, the density of stations to depend primarily upon funds available for the project. As a result of rather intensive work, covering a period of about 50 years, observations have been made at some 6,000 stations. Data from these observations have been compiled and brought up to date and are graphically represented in what is known as an isogonic chart of the United States. Similar charts have been compiled for horizontal and vertical intensities for the same area. Several of these stations have been selected to serve as so-called repeat stations, that is, stations at which observations are made at intervals of a few years for the determination of secular change. Experience has shown that it is reasonably safe to interpolate secular change in order to cover areas in which actual observations have *not* been made. While the isogonic chart gives a general picture of the situation as it applies to any particular magnetic element, it may not be safe to rely upon absolute values scaled from a chart or interpolated between two or more stations at which actual observations have been made. The primary reason for this is that the distribution of the earth's field is by no means so uniform as the large scale charts would seem to indicate. This lack of uniformity is due primarily, of course, to magnetic materials in the earth's crust, and it is well known that the composition of the crust is anything but uniform. If these magnetic materials or formations lie on or near the surface, their effects on the distribution of the field a few feet above the surface may be quite large. If the magnetic materials lie deeply buried under formations that are practically nonmagnetic, the distribution of the field at the surface may be relatively uniform and the chances of bringing some order out of the results by a reasonable number of observations may be fairly good. This condition exists generally in the western half of the Great Plains region of the United States, where the crustal layers near the surface consist of thick beds of limestone, overlaid by the so-called "loess" formation.

Fig. 6.—Magnetic observing tent and magnetic station at Kineo, Maine (Moosehead Lake), in 1910. Field observations are made within the tent to protect the instruments against wind, rain, or direct rays of the sun.

Many surprises, however, await the observer who is overoptimistic. One of the greatest of these surprises, in the experience of the author, happened in northwestern Iowa, a region in which one would not expect to find any large magnetic anomalies. Nevertheless, many areas were found in this region where the magnetic declination differed by 2 to 3 degrees within a radius of a few hundred feet, and tests indicated that this condition prevailed for miles around. The surface geology gave no indication that such conditions might exist. On the other hand, there are large areas where we know from experience that anomalies are the rule rather than the exception. In the eastern half of Idaho, the eastern half of Oregon, and the southern half of the State of Washington there are vast areas in which highly magnetic basalt lies on or just below the surface. Whether the basalt is *in situ* or is strewn over the area as talus or rubble, the magnetic disturbance is there. If these areas were only small, we could simply ignore them or by-pass them, but it is not so easy to by-pass or ignore the greater part of three whole States. Observations in such disturbed areas have shown that the direction and intensity of the field may vary over wide ranges with change in elevation above the surface. Differences of several degrees in declination have been observed by simply altering the height of the instrument. This is precisely what one should expect. Most of the land observations for declination and horizontal intensity are made with the center of the magnet at varying elevations of 4 to 5 feet above the surface of the ground, depending upon the height of the particular observer. This is fortunate, in a way, since the values found represent conditions as they exist in the layer or region above the surface where they will be most useful. But we should not be surprised if in a moderately disturbed area, a tall observer obtains values decidedly different from those obtained by another not so tall.

(Courtesy National Park Service)

Fig. 7.—Devils Tower, Wyo. A basaltic lava formation, usually quite magnetic, fragments frequently showing distinct polarity.

Let us take the not uncommon case where we have three stations located in a disturbed area. Suppose that the observed values of declination at stations *A*, *B*, and *C* are 22.7° E., 30.4° E., and 25.1° E. and that it is desired to know the value at some intermediate point *D*, within the boundaries defined by *A*, *B*, and *C*. It should be obvious, even to one who has never made magnetic

observations in such an area, that a mean value, a weighted mean value, or an interpolated value, under such conditions, will, more than likely, *not* represent the facts. The value at *D* may be much smaller or even much larger than those at *A*, *B*, and *C*. Even though observations are made systematically at hundreds of sites in the area, interpolated values would have little meaning. True, the average of all of them might closer represent the average value for the area at the elevation above the surface at which the observations were made, but nothing more. Suppose again that the area contains no natural magnetic material scattered about, but that we distribute promiscuously over the area hundreds of large bar magnets of sufficient size and moment to produce distortions of the kind we know exist in some disturbed areas. Would any practical magnetician, would any mathematician or physicist be so optimistic as to hazard a guess as to the probable value of a magnetic element at some random point in the area? I cannot answer for the mathematician or the physicist, but I can tell you what the practical magnetician would like to do about such a situation. He would recommend that the limits of the disturbance be delineated with reasonable precision, whether the disturbing cause be natural or artificial, and so indicate the area on the chart.

Let us now consider the case where it is desired that we know something about the declination or intensity on or near the surface of navigable waters such as a narrow channel or a bay or a harbor bordered by land areas that are known to be highly magnetic. If the land areas adjacent to the channel are highly magnetic, it is almost certain that the same condition exists at the bottom of the channel. The distribution of the field at any position above the surface of the water will depend not only upon the nature of the disturbance on shore and at the bottom but upon the depth of the water and the distance off shore. We know that these magnetic effects die out rapidly with distance, but we first must know something about the nature and extent of the disturbance before we can estimate even approximately what the effects are at a distance. Interpolation of declination values between two or more shore stations is about as risky as an attempt to estimate values of declination high above the surface of the earth by extrapolation. Either process might be reasonably safe if one could know something about the nature and extent of the disturbing influence, but if the data upon which calculations are based were obtained by assumptions the extrapolations may mean exactly nothing in practice.

I repeat, it is not possible to obtain a perfect picture of the distribution of magnetism in a highly disturbed area (disturbing influence near the surface) even though the area be covered with stations spaced every few feet horizontally and vertically. The average of observed values is simply the average value, nothing more. It tells you practically nothing about a particular value at a particular latitude, longitude, and elevation.

If the geological structure or formation causing the disturbance lies buried to some depth below the surface, then it is possible to make some order out of chaos, because of the fact that the effects die off rapidly with distance and the gradients become less steep. One of the most satisfactory instruments used in making a magnetic survey is the vertical-intensity field balance. This is similar in many respects to the laboratory or observatory instrument but is so designed that it can determine differences in the vertical component to a fairly high degree of accuracy in a short time and at comparatively low cost. Practically all the magnetic surveys made by oil companies have been carried out with instruments of this type. The technique is simple. One observer makes continuous or nearly continuous observations at a base station with one instrument while other observers cover the adjacent area with similar instruments. Following a definite program of checks and comparisons at the beginning and end of a day's routine it is possible to eliminate from the final results the effects of diurnal variation. A magnetic survey of central South Dakota has recently been completed by the South Dakota State Geological Survey,

and the results have been compiled as a vertical intensity chart. It would be almost impossible to complete a survey of this kind if the magnetic formation were at or near the surface. One of the great disappointments in a map of this kind is that it cannot be joined up readily to a similar adjacent chart. The values are all relative, no absolute value of the vertical intensity having been determined. Here again is a very practical problem and one that at present can be met to a limited extent by means of an earth inductor and a magnetometer. In other words, it is necessary to determine the absolute value of the vertical intensity at the base stations and then obtain the absolute values at any position in the survey by applying differences as obtained by means of the field balance. This method is satisfactory if one is satisfied with absolute values, the accuracy of which is no better than 40 to 50 gammas or about $\frac{1}{2}$ milligauss in the middle latitudes.

I have just tried to show that there is no particular problem in securing data of sufficient accuracy for magnetic charts in an undisturbed area, but that in highly disturbed areas the charts and tables may not represent actual conditions at random points in that area. We also know that a great many additional precise observations taken at random over large areas would not clarify the general picture a great deal; perhaps they would only tend to confuse us still more. The first important element in the whole observing program in the field is that the establishment and preservation of certain master repeat stations is recognized. Reasonably precise observations at these stations furnish the necessary data for revision of charts at regular intervals. The second important element is that there is urgent demand for special intensive surveys in limited areas.

If we had a perfect three-dimensional picture (motion-picture, by the way) both in direction and intensity of that portion of the earth's field that is useful in magnetic surveys and in other geomagnetic investigations, would it serve any more useful purpose than the picture we now possess? In general, I think not. In special cases, yes. In the first place, there are only a few individuals who would understand how to use the precise data, and in the second place there are comparatively few instruments so designed as to make possible the utilization of more precise data.

Now we have almost forgotten one of the most important elements in this whole observing program—the observer himself. Consider for a moment what happens when the observer, Mr. X, carries on a day's routine of magnetic work in some remote corner of the country. When observing conditions are ideal, the task is relatively simple, but experience has shown that ideal conditions rarely exist for the man in the field. It seems to be axiomatic that as soon as the observing program starts, all inanimate nature in the immediate neighborhood suddenly comes to life, as it were, and marshalls its forces to defeat the observer. The wind and the rain; the blistering heat or the freezing cold; the desert dust or the tropical humidity; yes, even animate nature in the form of swarms of persistent mosquitoes join the battle against the observer; but the show must go on. Occasionally none of these evil things seems to be on the alert, and then it happens, not infrequently, that the very elements being measured go on a rampage, and Mr. X finds himself in the midst of a magnetic storm that may last for days. Needless to say, it takes courage, strategy, stamina, and an almost insane desire on the part of the observer to complete the task. Any one of the opposing elements or forces may be the immediate cause of significant errors in the results. Compare these field conditions with those which are obtained at an observatory or in the laboratory. In the laboratory, reasonable safeguards have been set up to eliminate, neutralize, or compensate for the hostile elements, but in the field the observer is practically on his own. He must substitute strategy and judgment for the comforts and compensations of the laboratory and while being eternally vigilant and on the alert he must, at the same time, make scientific observations requiring the utmost in care and skill. Small wonder that, under average conditions in the field, some combination of

opposing forces or circumstances introduce elements that may influence the results adversely.

Let us now turn our attention to another branch of geophysics, seismology, or the science of earthquakes. In the instrumental and operational side of this science we find many problems strikingly similar to those one meets in geomagnetism. Instruments are developed and perfected in the laboratory and then they are scattered far and wide over areas to be investigated. Investigators have confined their attention principally to four main branches of the science—(*a*) The delineation or charting of worldwide seismic zones (teleseismic studies); (*b*) intensive studies of restricted areas (regional investigations); (*c*) seismic prospecting (search for oil, minerals, etc.); and (*d*) investigations of strong seismic motion (destructive earthquakes).

Owing to the great interest taken in teleseismic work in recent years, especially in the United States, it is now possible to locate rather quickly, and probably with sufficient accuracy for most purposes, the epicenters of practically all earthquakes that are of sufficient intensity to set up seismic waves that can be recorded at some distance by delicate instruments known as seismographs. Nearly all these seismographs are of the inertia type, in which a pendulum of some kind, horizontal or vertical, is set up in such a manner that its motion is restricted to one degree of freedom. The support for the pendulum is of rigid construction, and this in turn is rigidly attached to the underlying geological formation or foundation. When the foundation, that is, the ground, is displaced in the direction in which the pendulum is free to move, the pendulum has already made up its inanimate mind to try to remain at rest relative to its support and in general it succeeds reasonably well. The relative motion between the center of oscillation and the ground is a function of the ground period, the natural period of the pendulum, the degree of damping of the pendulum, and other factors. In ordinary teleseismic work these ground motions are usually extremely small at a recording station. Different methods have been devised for magnifying the apparent motion of the pendulum to such a degree that it can be detected or measured. This magnification may be accomplished mechanically, electromagnetically, electrostatically, optically, or by combinations of these methods. All modern seismographs are designed for continuous photographic registration. It is customary to set up two or three instruments oriented at right angles to each other, the idea being that two or three components of the motion will be recorded and thereby furnish data from which, theoretically at least, the complete ground motion can be deduced. Complete analysis would include displacement, velocity, acceleration, distance and direction to the epicenter, and perhaps some other elements of which the author has not yet been informed. It will not be possible, in a short paper, to describe all the different types of instruments now in operation. Their number is legion, but in general, their effectiveness (or their efficiency or their usefulness) is a function not only of the magnification and some other instrumental constants but also of their sturdiness and their ability to remain in adjustment and to operate reasonably well over long periods of time, far from home.

Let us take one of these modern teleseismic seismographs through some laboratory tests and then transport it to some remote seismological station, say in the West Indies or Alaska, and compare the results that we have obtained under laboratory conditions with those that we get in the field. The instrument to be described is of the electromagnetic type. To the steady mass is attached a coil of nonmagnetic copper wire, which is free to move with the steady mass in a strong, radial, magnetic field. The terminals of this coil are connected to a high-sensitivity galvanometer equipped with suitable optical parts for photographic registration. Shunted across this circuit is a variable resistance to provide proper damping. Essentially this is a motor-generator, or, in this case, a generator-motor. When the ground moves it takes everything else with it including the magnetic field of the seismometer magnets, but

the pendulum and the coil tend to remain at rest. We then have relative motion between coil and magnetic field; an emf is set up, and current flows in the circuit, and the galvanometer responds. The dimensions of the seismometer and the galvanometer have been so designed that for ground periods such as one encounters in teleseismic work the angular motion of the galvanometer is perhaps 5 to 20 times greater than the angular motion of the seismometer pendulum. Further magnification is obtained by optical lever so that the overall nominal magnification of the system is from 1,000 to 2,000, depending upon the particular instrument.

One of the methods of testing the efficiency of a seismometer is to place it on a shaking table, the motions of which can be controlled arbitrarily and measured accurately. Since the magnification of the teleseismic instrument is usually high, it is necessary that such a shaking table be of sturdy construction and supported on a firm foundation so that one may be assured that the measured motions of the table relative to the ground are reasonably accurate. In cooperation with the Survey, such a shaking table was set up at the National Bureau of Standards a few years ago. It consisted essentially of a triangular slab of concrete suspended near each vertex by piano wires attached to rigid concrete piers, which were poured upon and rest upon natural, undisturbed, leached gneiss. The whole apparatus was located in a room about 30 feet below the ground level so that there was reasonable assurance of stability. Table displacements as small as 1 micron could be recorded without difficulty. The seismometer just described was mounted upon this table along with two other seismometers of radically different type, and the responses of the different instruments to known motions of the table were measured and compared. Also, the responses of the different instruments to harmonic motions varying in frequency from 30 cps to 1 cycle in 30 seconds were determined, thereby furnishing data from which so-called magnification curves were prepared. The character of the response records for the three different instruments show remarkable similarity. The electromagnetic seismograph was then subjected to critical routine operating tests for several months, after which it was installed and placed in routine operation in the Franklin Institute, at Philadelphia, where it has been in continuous operation, without appreciable interruption, for several years. This is a remarkable record and is a good example of what can happen when an instrument is operated at a station where conditions are quite as satisfactory as they would be in the best of laboratories. The efficiency or effectiveness of this instrument in recording ground motion is well illustrated in the Franklin Institute records of an earthquake that occurred on April 15, 1941, about 3,600

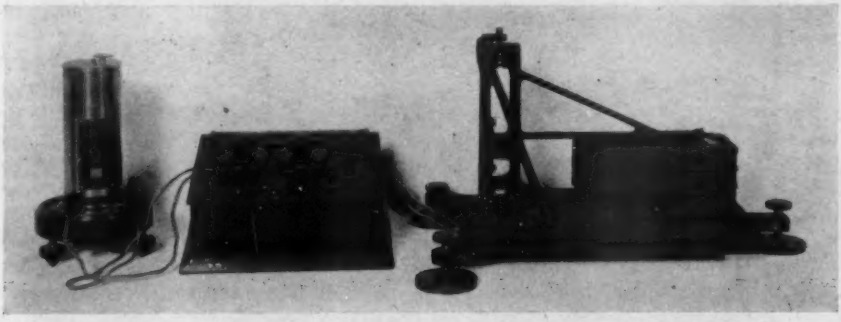


Fig. 8.—Wenner seismometer, bridge, and commercial galvanometer modified for photographic recording. A modern electromagnetic type of seismometer used in teleseismic registration.

kilometers southwest of Philadelphia. The azimuth of the epicenter was in the neighborhood of 45° to each of the two horizontal component instruments, and the seismograms are almost duplicates, at least for the first 2 or 3 minutes. When earthquake waves and instruments behave in this manner it is not difficult to estimate the azimuth of the epicenter, but performance of this kind is the exception rather than the rule.

With electromagnetic instruments having small dimensions and high magnification it should be apparent at once that the magnetic field in which the seismometer coil moves must be reasonably uniform over the full range of motion if the sensitivity of the system is to be uniform over that range. This matter has been investigated fully and the latest instruments of this type have been adjusted to this condition. Also the system has been equipped with a so-called dynamic tester, which permits testing the sensitivity of the individual components quickly and accurately under routine operating conditions. Such tests, if recorded daily, furnish data that can be used in estimating the approximate nominal magnification of the particular component at that time. While these devices have proved highly satisfactory in extended laboratory tests, they have not shown much promise in the field.

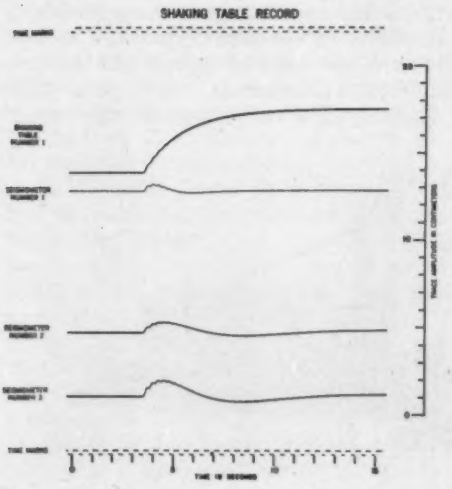


Fig. 9.—Shaking table record showing the response of three different types of seismometer to a sudden displacement of the table. The table motion is magnified about 400 times.

Instruments of the type described above and equipped with dynamic testers, after having passed their physical examination and laboratory tests, have recently been placed in routine operation in San Juan, Puerto Rico. Experience has shown that in a climate where the humidity is excessive and the mean temperature rather high many things can happen to a delicate instrument in a comparatively short time. A minute growth of fungus, perhaps invisible to the unaided eye, may contrive to be born and flourish in the most inaccessible part of the instrument, and if it obstructs the motion of the pendulum or the galvanometer in the slightest degree, the usefulness of that instrument is precisely zero. Extra precautions have been taken to seal up these instruments and operate them in air that has been thoroughly dried. Such precautions are usually not considered necessary even in extended laboratory tests, but they seem to be imperative in the tropics. Once an instrument is placed in operation in the field, however, its usefulness is measured by its continuity of service since if frequently out of commission for one reason or another it may not be operating when the unpredictable earthquake waves arrive. Its primary function is to record them, *all of them*, when they do arrive. It frequently happens that the type of instrument that produces records that are the best from the point of view of the seismologist who must interpret these records is the one that is most difficult to keep in operation in remote places. For this reason we usually find it necessary to compromise by sacrificing perfect performance of limited duration for reasonably good performance with no interruptions.

We have tried to follow this same policy in our program of investigation of strong seismic motion. When this project was initiated several years ago by the Coast and Geodetic Survey there was little reliable information available upon which to formulate a program of attack. But the heat was on, funds were appropriated for the project,

and it was necessary to achieve some kind of success in a few short months lest the support be withdrawn because we had accomplished nothing. The seismological literature was searched, seismologists, mathematicians, physicists, geologists, and structural engineers were canvassed and consulted for advice. After all the available evidence was in, a decision was made. We would concentrate on strong motion accelerometers; but, lest we find ourselves on the wrong track, allotments were made for a few instruments of other types. The work was divided up among cooperative agencies. Out of the National Bureau of Standards came the accelerometer; from the University of Virginia came an intermediate period mechanical instrument; from funds provided by the National Research Council came the tiltmeters; and from the Survey came the strong-motion displacement-meters, vibration meters, and the automatic recorders for use with the accelerometers. The recorder in combination with a group of three accelerometers is now known as an accelerograph. Again it is quite impossible here to describe all these instruments. Since our major effort has been concentrated on the accelerograph, it will receive the attention here.

The original accelerometer consisted essentially of a copper loop supported rather rigidly by a quadrifilar suspension. The copper loop served the double purpose of steady mass and damping vane and was so arranged as to oscillate between the pole pieces of a strong permanent magnet. In reality it was a miniature, short period, low magnification, optical, seismometer. It was subjected to some laboratory tests with experimental recorders, and since it gave promise of meeting requirements it was placed in quantity production. Within a comparatively short time 10 complete, three-component accelerographs were in routine, stand-by operation in seismic zones on the west coast. The field installations came none too soon. Within three months came the Long Beach earthquake, and all the accelerographs in that area operated and furnished records that were reasonably good when all the circumstances are taken into consideration. It was apparent at once, however, that certain improvements were

Fig. 10.—Typical accelerograph station in a seismic area. The whole instrument is securely bolted to a concrete pier and is protected by a metal cover. Note that storage batteries, which supply light and power for operation of the instrument, are lashed to the pier to guard against interruption of power during a major earthquake.

quite essential especially in the matter of recording. Also, the quadrifilar suspension, while its performance in the laboratory was eminently satisfactory and although it could be adjusted and tuned within a reasonable time, presented quite a problem in the field, especially since there were 30 of them to keep in adjustment. One cannot spend all his time making adjustments. Otherwise, the earthquakes might never have an opportunity to make use of the accelerometers. As a result of further laboratory experiments and tests, the pivot accelerometer was developed and at the same time combined with a low-magnification attachment, which, it is believed, will record the strongest shocks without loss of record. Since there are now about 150 of these units in operation in the United States, it is quite obvious that servicing these instruments is no small task. While we may have sacrificed accuracy in some degree by the use of pivot instruments, they have made it possible, because of their ease of assembly and adjustment, to keep the program going.

In cooperation with the Massachusetts Institute of Technology the Survey has conducted some shaking table investigations with these accelerographs. The whole ac-

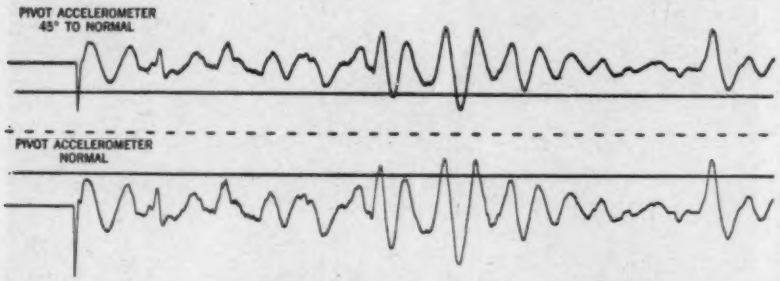


Fig. 11.—Shaking table record at Massachusetts Institute of Technology showing response of two pivot accelerometers to sudden and irregular motions of the table. One accelerometer is oriented at 45° to the direction of motion. The time marks (broken line) are spaced at one-half second between centers.

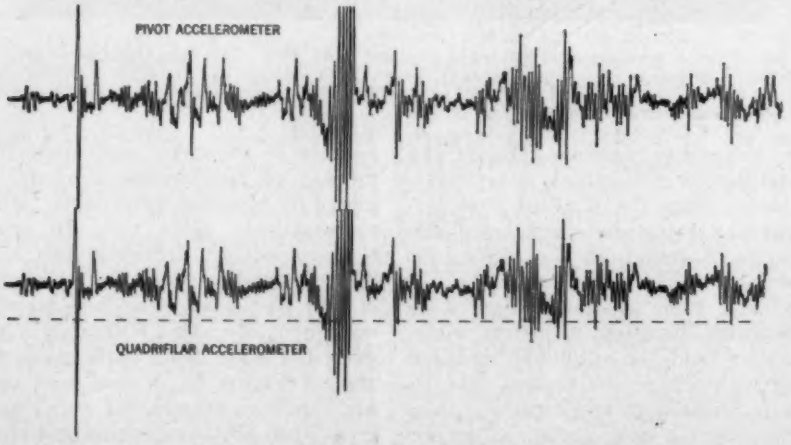


Fig. 12.—Shaking table record at Massachusetts Institute of Technology showing response of pivot and quadrifilar accelerometers to the same table motion. Time marks (broken line) are spaced at one-half second between centers.

celerograph was mounted upon a sturdy shaking table, which was so designed that oscillations of variable frequencies and amplitudes as well as irregular motions could be obtained. By means of an ingenious photoelectric device the table was made to simulate the ground motion to which one of the accelerographs was subjected in the Long Beach earthquake. The accelerograph then reproduced with considerable fidelity the accelerogram that had been recorded originally at Long Beach. In one of the tests a pivot accelerometer and a quadrifilar accelerometer were allowed to record simultaneously. Casual examination of the records would seem to indicate that they are duplicates. Intensive study, however, has shown that if an attempt is made to derive ground displacements from the records made with pivot instruments, serious discrepancies appear that seem to be due primarily to slight shifts of the pivots in their bearings. These discrepancies may or may not be of engineering significance. Only time and possibly further experiments may decide the matter.

There is still much to learn about the dynamics of destructive earthquakes. We do know, of course, that when one of these major earthquakes occurs near a center of population the loss in life and damage to property may be terrific. We know also that certain engineering structures are totally demolished while others nearby escape with only slight damage. As a result of rather intensive investigations in engineering laboratories and owing in no small part to our own field work in connection with the determinations of natural periods of engineering structures when subjected to artificial vibrations, building codes have been improved in certain States to the extent that some kind of earthquake-proof construction must be included in specifications before building permits will be issued.

We do not know when or where earthquakes are likely to occur in the future, but it does not seem unreasonable to expect that most of the earthquakes of the future will continue to occur in regions where they have occurred before, that is, in seismic zones. However, wishful thinking or expert opinions to the contrary will not prevent them from happening anywhere on the earth, but that phase of the problem must be left for time alone to solve. It is believed that the published results of our investigations of strong seismic motion have been effective in convincing engineers and others that by exercising reasonable precautions in their building specifications, property damage and loss of life during a major earthquake may be reduced considerably. If our influence along this line has contributed in any degree whatsoever to the saving of life and property, our efforts have not been in vain.

In conclusion I should like to make a few remarks about the necessity of *keeping on the track* in carrying on this geophysical work. If it is our appointed duty to collect certain data in the laboratory or in the field, or if it falls to our lot to translate these data into language that the public can understand and use, then let us stay on the track and do that job. Whether or not we may like it, all of us must perform a certain amount of deadly routine. Until we learn that lesson and learn it thoroughly we cannot solve these geophysical problems nor can we keep the production line moving.

If, while I am supposed to be standardizing a magnetometer I spend weeks and weeks determining the induction factor of one of its magnets to an accuracy of 0.1 percent when I am fully aware of the fact that I need to know it to an accuracy of only 5 percent, I may be having a perfectly jolly time—yes, I may be thrilled with the results, but I have lost sight of my objective —I am off the track. By the same token, if the statistician who is compiling and publishing geophysical data insists on extracting the last drop of tribute from his instruments or from the man on the firing line who is operating them, sooner or later he will find that his production line is not moving ahead but has stopped. That statistician has indicted himself under an old but unrepealed statute—*the law of diminishing returns.*

ZOOLOGY.—*A new species of Amphipoda from Uruguay and Brazil.*[1]

CLARENCE R. SHOEMAKER, U. S. National Museum.

In July, 1941, some amphipods of the genus *Hyalella* Smith, taken in the river Imbé, a stream flowing into Lake Tramandai in the State of Rio Grande do Sul, Brazil, were sent to the U. S. National Museum for identification. These specimens superficially resembled *Hyalella azteca* var. *inermis* Smith, but, upon dissection, characters were observed that distinguish them from that form of *Hyalella azteca* (Saussure). I am, therefore, describing them as a new species, as follows:

Hyalella curvispina, new species

Male.—Eye dark, slightly reniform or oval. Antenna 1 about as long as the head plus the first three or four body segments and reaching to about the middle of the flagellum of antenna 2. Peduncular joints successively shorter and narrower; flagellum longer than peduncle and composed of about 11 joints, which do not carry sense-organs. Antenna 2, fifth peduncular joint longer than fourth; flagellum much longer than peduncle and composed of about 14 joints, which do not carry sense-organs.

Right mandible, molar strong and well developed, seta on inside edge and a tuft of setules at base between it and spine-row, which contains two long and one shorter spine; cutting-edge toothed and accessory plate well developed and toothed; a knoblike protuberance on inside surface at base of molar. Maxilla 1, inner plate with two apical plumose setae; outer plate with nine serrate and pectinate spine-teeth; palp small and ending in a narrow sharp point. This palp is much smaller in proportion than in *H. azteca*. Maxilla 2 normal, inner plate shorter than outer and bearing, in addition to the terminal spines, two plumose setae on upper inner margin. Maxillipeds, inner plate longer than outer plate and reaching beyond the middle of outer plate, the truncate upper margin armed with three teeth; outer plate rather short, inner margin armed with two or three rows of slender spines, but no spine-teeth; palp rather short and broad with the inner distal corners of the second and third joints produced into lobes; fourth joint rather weak and bearing a long slender nail.

Gnathopod 1 shorter and stouter than in *H. azteca;* fifth joint subequal in length to sixth, lobe of lower margin bearing a row of long and short spines; sixth joint a little longer than wide, palm oblique and convex, armed throughout with a row of slender spines, and defined by a lobe bearing a short spine, below which on the inside surface of joint is a similar spine; hind margin of joint bearing a slender spine and an armament of the minute pectinate scales which occur also in *H. azteca;* the front margin also bears a spine near the middle and an armament of pectinate scales distally; seventh joint fitting palm, bearing a nail and a few pectinate scales on outer margin, and a row of minute spinules on inner margin. Gnathopod 2 rather short and robust; palm quite oblique, convex and with only a mere suggestion of the tooth normally found near the hinge of the seventh joint in *H. azteca*. The hind margin of sixth joint is rather short and somewhat produced or lobed at the defining angle of palm; the inner surface of the defining lobe of the palm bearing an armament of pectinate scales. Seventh joint fitting palm with the apex dipping into a shallow pocket.

Peraeopods 1 and 2 much alike in shape and spinous armature, but 2 slightly the longer. Peraeopods 3 to 5 much alike but increasing consecutively in length, second joints much expanded with lower hind margin produced into a broad rounding lobe.

Lower hind corners of metasome segments 2 and 3 somewhat produced and sharply angular. Uropods not very spinose, but the inner ramus of uropod 1 bearing on the inner margin usually one but sometimes two long slender curved spines which are very characteristic of the males of this species. Uropod 3 with ramus subequal in length to peduncle. Telson as long as wide, reaching to about the end of peduncle of uropod 3, and bearing apically two stout spines and several slenderer and shorter spines. Length of male 9 mm from front of head to end of uropod 1.

The gill arrangement is the same in both

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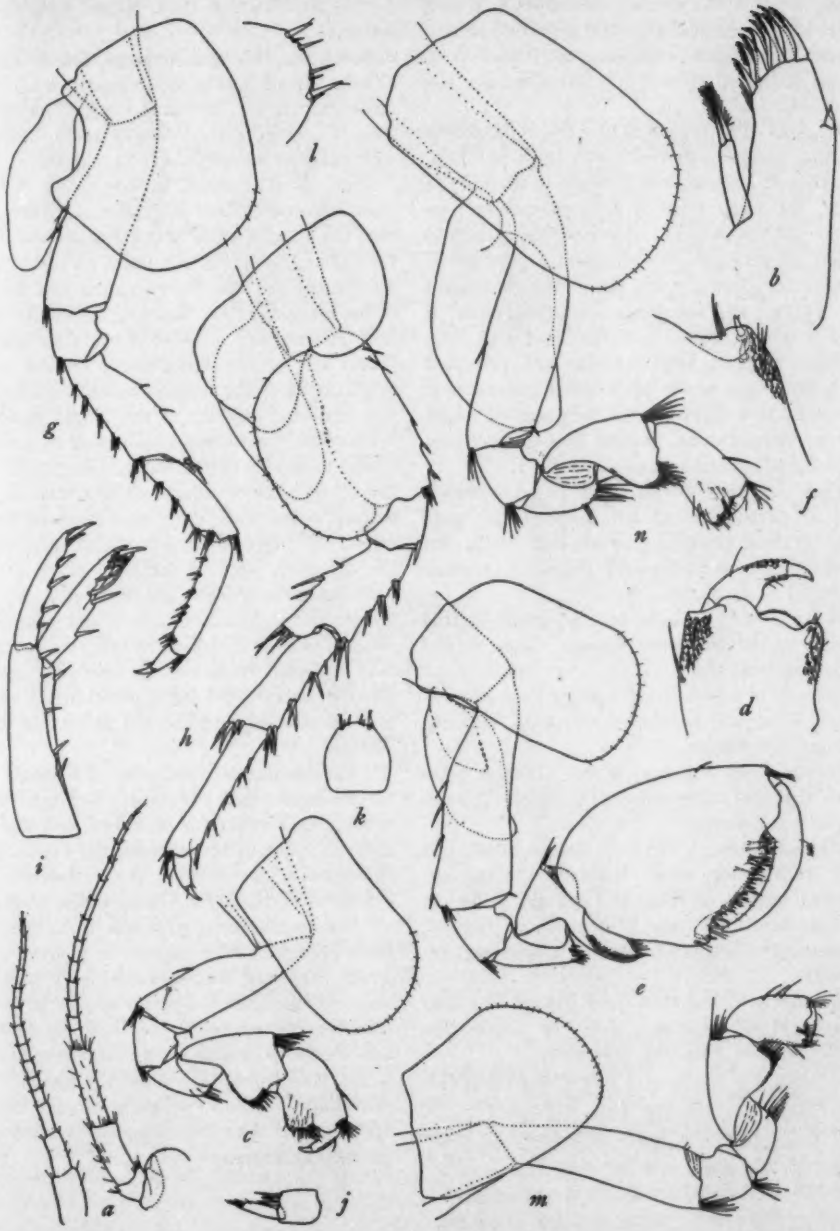

Fig. 1.—*Hyalella curvispina*, new species: Male: *a*, antenna 1 and antenna 2; *b*, maxilla 1; *c*, gnathopod 1; *d*, end of gnathopod 1 showing the pectinate scales on inside surface of joint; *e*, gnathopod 2; *f*, defining angle of palm of gnathopod 2 showing the pectinate scales on inside surface; *g*, peraeopod 2; *h*, peraeopod 3; *i*, uropod 1; *j*, uropod 3; *k*, telson; *l*, end of telson showing spines. Female: *m*, gnathopod 1; *n*, gnathopod 2.

sexes. Each of the mesosome segments 2 to 6 bears a pair of coxal gills and a pair of simple lateral sternal gills, while segment 7 bears only a pair of lateral sternal gills. This species has no dorsal teeth.

Female.—The female is like the male except in the gnathopods and the first uropod. Gnathopod 1 is longer and slenderer than in the male; the sixth joint is proportionately narrower and the palm is transverse; the front and hind margins bear a few spines and a few pectinate scales. Gnathopod 2 much like gnathopod 1 but longer and slenderer; sixth joint equal in length to fifth, widening distally and with palm slightly chelate; hind margin well provided with pectinate scales on inner distal surface. Uropod 1 does not have the long curved spines on the inner ramus. Length of female 9 mm from front of head to end of uropod 1.

Type locality.—Small mud puddles which dry up in summer (5 to 15 cm deep), near Montevideo, Uruguay, December, 1932, Ricardo Thomsen, collector. Type, a mature male, U. S. N. M. no. 79388.

Other records.—There are specimens of this species in the National Museum taken at the following localities:

Paso de la Arena (fresh water), near Montevideo, Uruguay, November 27, 1925, Ricardo Thomsen, collector.

Montevideo, Uruguay (from General Buzzano's Place), December 10, 1925, Ricardo Thomsen, collector.

Pajas Blancas, quite near the sea coast, but still fresh water, near Montevideo, Uruguay, December 7, 1932, Ricardo Thomsen, collector.

Carrasco Creek, near Montevideo, Uruguay, December 11, 1925, Ricardo Thomsen, collector.

From a well, 20 meters deep, subsoil line, near Montevideo, Uruguay, July or December, 1932, Ricardo Thomsen, collector.

Among the roots of *Pontederia* and *Rhynchospora* in the river Imbé, flowing into the Lagoa de Tramandai; littoral of Rio Grande do Sul, Brazil, June, 1941, Herm. Kleerekoper, collector.

Remarks.—The gill arrangement is slightly different from that of *Hyalella azteca* of North America. In *H. azteca* there are no lateral sternal gills on the second body segment, whereas they are present in *H. curvispina.*

Prof. A. S. Pearse, in describing *Hyalella ornata* from the State of Veracruz, Mexico, said that the specific name was given on account of the tubercles that cover parts of the anterior margins of the last two segments and the posterior margins of the last four segments of the first gnathopods of both sexes and that are found also on the same places on the second gnathopods of the female, but appear only on the posterior margins of the fourth and sixth segments of the second gnathopods of the male. These tubercles, when highly magnified, have the appearance of oblong scales armed on their convex edges with very minute teeth or spinules, which give them a pectinate appearance. On the sixth joint of the first gnathopods of both sexes these scales are directed away from the central longitudinal axis of the joint on the outside surface and toward the axis on the inside surface. Those of the seventh joint are directed away from the inner concave margin on the outside and toward it on the inside surface.

I have examined specimens of *Hyalella* from several localities in the state of Veracruz, which is the type locality for *H. azteca,* and find that they all possess these pectinate scales. I am therefore of the opinion that *H. ornata* is a synonym of *H. azteca.* These scales appear on all the specimens of *Hyalella* from Mexico I have been able to examine. In passing northward, westward, and eastward from Mexico in the United States the scales appear to become considerably less in number and less conspicuous. I believe that all the specimens of *Hyalella* I have seen from Mexico and the United States are *Hyalella azteca,* which is a very variable species, and that they all possess these scales in varying degrees.

ICHTHYOLOGY.—*The first record of the ophichthyid eel* Scytalichthys miurus *(Jordan and Gilbert) from the Galapagos Islands, with notes on* Mystriophis intertinctus *(Richardson).*[1] LEONARD P. SCHULTZ, U. S. National Museum.

In identifying a small collection of fishes made by Dr. Waldo L. Schmitt in the Galapagos Islands, I had opportunity to study a specimen of *Scytalichthys miurus* (Jordan and Gilbert). Jordan and Davis (Rept. U. S. Comm. Fish and Fisheries for 1888, pt. 16, pp. 634–636. 1892) described the subgenus *Scytalichthys*, genotype *Ophichthys miurus* Jordan and Gilbert, and based the generic distinction on "vomerine teeth in one series of about four slender depressible canines; tail very short, much shorter than rest of body." Jordan and Evermann (U. S. Nat. Mus. Bull. 47, pt. 1, pp. 386–387. 1896) copied Jordan and Davis in their generic description. It is my good fortune to have at hand all the specimens studied by those authors, as well as some additional specimens. The vomerine teeth of the types of *Ophichthys miurus* Jordan and Gilbert, U. S. N. M. no. 2304, are fixed and not depressible or movable (except where broken loose from their bases). Although the types of *S. miurus* are small specimens, the teeth have the same arrangement as in the larger specimen (total length 685 mm) collected by Dr. Schmitt in Aeolian Bay, South Seymour Island, April 11, 1941, U. S. N. M. no. 119785. From the above-mentioned specimens I have made a sketch of the teeth giving the actual number of teeth in the jaws as counted by me along with their relative sizes (Fig. 1, *a*).

Closely related to *S. miurus* is *Mystriophis intertinctus* (Richardson) from the West Indies to the region of Florida. The arrangement of the teeth in this species is similar but very distinct from that in *S. miurus*. After examining all seven specimens available (U. S. N. M. nos. 6956, St. Thomas, W. I.; 23635 and 49797, Florida; 5984 and 31891, Florida), I made a sketch of the dentition of *M. intertinctus* showing the relative number of teeth and their relative sizes (Fig. 1, *b*).

A comparison of the dentition of these two species indicates without exception that the vomer and dentary have but a single row of caninelike teeth on *S. miurus* but a double row on *M. intertinctus*. The teeth on the maxillary of *S. miurus* are in two rows anteriorly and four rows posteriorly, but on *M. intertinctus* in but two rows. The teeth at front of upper jaw are likewise entirely different. It is concluded therefore that since these differences are so great the two species should be considered generically distinct. Thus *Scytalichthys* should be given full generic rank as was done by Jordan, Evermann, and Clark (Rept. U. S. Bur. Fish. for 1928, pt. 2, p. 89. 1930) but not on the basis of *depressible canines on the vomer*. It should be based instead, among other characters, on the dentition as indicated in this study, on the small pectoral fins that are 1¼ length of eye, and origin of dorsal fin one head length behind gill openings.

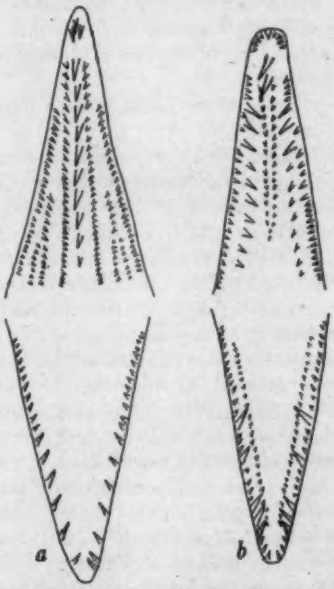

Fig. 1.—*a*, Dentition of *Scytalichthys miurus* (Jordan and Gilbert); *b*, dentition of *Mystriophis intertinctus* (Richardson).

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PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

372D MEETING OF THE BOARD OF MANAGERS

The 372d meeting of the Board of Managers was held in the private dining room of the Cosmos Club on Friday, January 9, 1942. In the absence of President CLARK, Vice-President H. E. MCCOMB called the meeting to order at 8:10 P.M., with 14 persons present as follows: H. E. MCCOMB, F. D. ROSSINI, N. R. SMITH, W. W. DIEHL, J. H. KEMPTON, F. C. KRACEK, F. G. BRICKWEDDE, M. C. MERRILL, W. A. DAYTON, H. L. CURTIS, L. W. PARR, C. L. GARNER, and, by invitation, R. J. SEEGER and G. A. COOPER.

The minutes of the 371st meeting were read and approved.

For the Executive Committee, the Secretary reported that this committee met at the Cosmos Club on December 5, 1941, at 9:30 P.M., with Messrs. A. H. CLARK, H. L. CURTIS, J. E. GRAF, and F. D. ROSSINI present, to review the action recently taken by the Committee with regard to the investment of $5,200 that has come into the treasury from the closing out of two previous investments (see minutes of the Board of Managers meeting on November 7, 1941, and October 3, 1941). The Committee considered investing these funds in 4½ per cent cumulative preferred stock of the Citizens Bank of Takoma Park, Md., which stock was currently available for purchase, but agreed that the reinvestments should be made as previously planned, namely, investment in savings accounts in federally-insured savings and loan associations, the total amount in each to be not more than $5,000. The Treasurer was further authorized to transfer $300 from the checking account to the funds for reinvestment to make the total $5,500. Of this amount, $500 and $1,000 are to be added to the accounts in the Northwestern Federal Savings and Loan Association and the First Federal Savings and Loan Association, respectively, bringing the total in each to $5,000. The remaining $4,000 is to be placed in a third federally-insured savings and loan association.

For the Committee on Meetings, Chairman GARNER reported the speaker for the February meeting to be GEORGE C. VAILLANT, director of the Museum of the University of Pennsylvania, Philadelphia, Pa.

For the Committee on Membership, Chairman KRACEK presented nominations for membership for six persons, four honorary and two nonresident.

The Committee of Tellers appointed to canvas the votes on the affiliation of the Washington Section of the American Society of Civil Engineers, L. B. TUCKERMAN (chairman), R. W. BROWN, and GEORGE TUNELL, presented their report as follows: The Committee met on December 9, 1941. It compared the ballot envelopes with the list of the members of the Academy in good standing and found 202 ballots from members in good standing; 2 ballots from members in arrears; 1 ballot in unsigned envelope; total 205. The count of the ballots from members in good standing showed: For affiliation 196; against affiliation 6; total 202. The Board formally declared the Washington Section of the American Society of Civil Engineers affiliated with the Academy.

The Secretary reported the following data concerning membership: Deaths, 1; acceptances to membership, 6; qualified for membership, 4; retirements, 2. The status of the membership as of January 8, 1942, was:

	Regular	*Retired*	*Honorary*	*Patrons*	*Total*
Resident	435	33	3	0	471
Nonresident	128	18	13	2	161
Total	563	51	16	2	632

Under new business, the Board authorized the appointment of two committees: One to study the matter of the affiliation of the Academy with the American Association for the Advancement of Science; and the other to consider questions relating to the Committee on Membership, involving the establishment of a greater continuity in the personnel of the Committee and general criteria for honorary membership. The meeting adjourned at 9:40 P.M.

309TH MEETING OF THE ACADEMY

The 309th meeting of the Academy was held in the Assembly Hall of the Cosmos Club at 8:15 P.M. on January 15, 1942, with Vice-President H. E. MCCOMB, representing the

Philosophical Society, presiding. The retiring president of the Academy, AUSTIN H. CLARK, delivered an address entitled *Science and war*, which was published in the February 15, 1942, issue of the JOURNAL. Following his address, President CLARK took the chair and adjourned the meeting at 9:15 P.M.

44TH ANNUAL MEETING OF THE ACADEMY

The 44th annual meeting of the Academy was held on January 15, 1942, immediately following the 309th regular meeting of the Academy. President CLARK called the meeting to order at 9:25 P.M., with about 75 persons present. The minutes of the 43d annual meeting were approved as published on pages 155 to 164 of the JOURNAL of April 15, 1941.

Report of the Secretary

The Secretary presented the following report for 1941:

During 1941 a total of 39 persons (32 resident and 7 nonresident) were elected to membership, all of whom accepted. Of these, 11 were elected in recognition of their work in chemistry, 5 in zoology, 3 in entomology, 3 in physics, 2 in agronomy, 2 in geology, and 1 each in anthropology, astronomy, bacteriology, biochemistry, cartography, cytology, engineering, helminthology, horticulture, medicine, parasitology, plant pathology, and public health.

Because of their retirement from active work, 10 members (5 resident and 5 nonresident) were placed on the "retired" list. Resignations were accepted from 9 members in good standing (4 resident and 5 nonresident).

During 1941, 10 deaths (7 resident and 3 nonresident, including 1 patron) were reported to the Secretary as follows:

MRS. HENRY L. HIGGINSON, Boston, Mass., May 6, 1935.
MAX WEBER, Amsterdam, The Netherlands, February 7, 1937.
WILLIAM WILLIAMS GILBERT, Washington, D. C., December 22, 1940.
DAYTON CLARENCE MILLER, Cleveland, Ohio, February 22, 1941.
MORTON GITHENS LLOYD, Washington, D. C., April 26, 1941.
ERNEST WERNER EICKELBERG, Washington, D. C., May 20, 1941.
CLAUDE HALE BIRDSEYE, Washington, D. C., May 30, 1941.
DAVID IVES BUSHNELL, JR., Washington, D. C., June 4, 1941.
HUGH MCCORMICK SMITH, Washington, D. C., September 28, 1941.
ERNEST EVERETT JUST, Washington, D. C., October 27, 1941.

On January 1, 1942, the membership was as follows:

	Regular	*Retired*	*Honorary*	*Patrons*	*Total*
Resident	433	33	3	0	469
Nonresident	127	18	13	2	160
Total	560	51	16	2	629

During the period from February 7, 1941, to January 9, 1942, the Board of Managers held seven meetings, with an average attendance of 17 persons. One of two special committees carried over from 1940 completed its work. Of the six special committees appointed by the President during the past year, four completed their work and two will carry over.

During the past year, the Academy held seven meetings, beginning with the 303d and ending with the 309th, as follows:

On February 20, 1941, jointly with the Philosophical Society of Washington, with an address by P. W. BRIDGMAN, of Harvard University, entitled *The changing position of thermodynamics*.

On March 20, 1941, for the presentation of the Academy's Awards for Scientific Achievement for 1940, to HARRY DIAMOND, of the National Bureau of Standards, in the engineering sciences, and to FERDINAND G. BRICKWEDDE, of the National Bureau of Standards, in the physical sciences.

On April 17, 1941, to hear reports on various phases of the 1940 South American Eclipse Expedition, sponsored by the National Geographic Society and the National Bureau of Standards, from IRVINE C. GARDNER, CARL C. KIESS, and THEODORE R. GILLILAND, of the National Bureau of Standards, PAUL A. MCNALLY, S. J., of Georgetown University, and EDWARD O. HULBERT, of the U. S. Naval Research Laboratory.

On October 16, 1941, jointly with the Philosophical Society of Washington and the Washington Society of Engineers, with an address by FRANCIS W. REICHELDERFER, of the U. S. Weather Bureau, entitled *Some famous weather maps*.

On November 27, 1941, jointly with the Anthropological Society of Washington, with an address by MATTHEW W. STIRLING, of the

Bureau of American Ethnology (assisted by Mrs. Stirling), entitled *Treasure trove of Mexican archeology*.

On December 18, 1941, jointly with the Washington Section of the American Institute of Electrical Engineers, with an address by KARL B. MCEACHRON, of the General Electric Company, entitled *Lightning*.

On January 15, 1942, with an address by AUSTIN H. CLARK, the Retiring President of the Academy, entitled *Science and war*.

Accounts of the first five of these meetings have been published in the JOURNAL under the Proceedings of the Academy, and the last two will soon appear. One of the meetings was held in the Auditorium of the U. S. National Museum and the other six in the Assembly Hall of the Cosmos Club.

On January 9, 1942, the Board of Managers formally declared the Washington Section of the American Society of Civil Engineers affiliated with the Academy, as a result of the favorable vote of the membership of the Academy in a balloting by mail which began November 10, 1941, and ended December 9, 1941. There are now a total of 20 societies affiliated with the Academy. On motion, the report of the Secretary was accepted.

Report of the Treasurer

The treasurer, H. S. RAPPLEYE, submitted the following report for 1941:

CASH RECEIPTS AND DISBURSEMENTS

RECEIPTS:	
From dues 1939	$ 5.00
From dues 1940	95.00
From dues 1941	2,470.80
From dues 1942	55.00
From subscriptions 1940	8.70
From subscriptions 1941	543.90
From subscriptions 1942	245.70
From sales of JOURNALS	458.76
From sales of Directory	26.85
From payments for reprints	535.49
From interest on deposits	48.89
From interest on investments	928.88
From sale of Butler notes	1,190.12
From sale of Ell & Kay property	4,000.00
From withdrawn for investments	8,500.00
Total receipts	$19,113.09
Cash balance Jan. 1, 1941	1,120.52
To be accounted for	$20,233.61
DISBURSEMENTS:	
For Secretary's Office 1941	$ 499.24
For Treasurer's Office 1941	202.12
For JOURNAL printing 1940	250.36
For JOURNAL printing 1941	2,407.42
For JOURNAL reprints 1940	30.99
For JOURNAL reprints 1941	567.66
For JOURNAL illustrations, 1940	23.93
For JOURNAL illustrations, 1941	253.83
For Custodian & Subs. Mgr., 1941	37.79
For Custodian & Subs. Mgr. (Special)*	108.50
For JOURNAL Office, 1940	24.33
For JOURNAL Office, 1941	242.02
For Meetings Committee, 1940	46.25
For Meetings Committee, 1941	306.70
For Directory, 1941	341.35
For dues returned	10.00
Total Disbursements	$ 5,352.49

* Special fund allotted to Subs. Mgr. to buy odd copies of JOURNAL.

Bank debit memos as follows:

Dues, 1941	$ 6.29	
Subscriptions, 1941	1.59	
Subscriptions, 1942	1.38	
Interest on investments	20.00	
		$ 29.26
Deposited in Savings Account		48.89
		$ 5,430.64
Cash Balance Dec. 31, 1941		4,802.97
		$10,233.61
Invested in Northwestern Federal Savings & Loan Assn.		5,000.00
Invested in First Federal Savings & Loan Assn.		5,000.00
Total		$20,233.61

RECONCILIATION OF BANK BALANCE

Balance as per cash book 12-31-41		$4,802.97
Bank Balance American Sec. & Trust Co. per statement 12-31-41	$4,930.15	
Receipts not deposited	25.25	
	$4,955.40	

Checks outstanding, not cashed:

No. 170	$21.50		
791	16.25		
792	9.00		
793	5.00		
794	1.50		
795	13.50		
796	33.15		
797	46.89		
798	5.64	152.43	
			$4,802.97

INVESTMENTS

409	Shares stock of Washington Sanitary Improvement Co., par value $10 per share, cost	$ 4,090.00
20	Shares stock Potomac Elec. Power Co., 6% Pref., cost	2,247.50
4	Certificates Corporate Stock of the City of New York, 1 for $500 and 3 for $100, cost	800.00
1	Bond of Chicago Railways Co., #1027; interest at 5%, due 1927; par value $1,000 less $250, cost	713.87
1	Real Estate Note of T. Q. Donaldson (#6 of 12) dated June 26, 1937 (extended to 1943); interest 5%; cost	1,000.00
2	Real Estate Notes of Yetta Korman et al., dated October 5, 1938 for 3 years (#7 of 37 for $500, and #8 of 37 for $500); cost. Extended from 1941 to 1944 with interest at 4½%	1,000.00
**2	Certificates (1 for $4,000 and 1 for $1,000)—First Federal Savings & Loan Assn., Nos. 914 & 1063	5,000.00
**2	Certificates (1 for $4,500 and 1 for $500)—Northwestern Federal Savings and Loan Assn., Nos. 1380 and 1441	5,000.00
	Deposited in savings account, American Sec. & Trust Co.	45.75
		$19,897.12
	Cash book balance Dec. 31, 1941	4,802.97
	Total Assets	$24,700.09

Total Assets Dec. 31, 1940	$25,468.75
Total Assets Dec. 31, 1941	24,700.09
Decrease	$ 768.66

* These certificates were purchased with the approval of the Executive Committee of the Board of Managers with money received from the following sources:

Butler Notes	$1,190.12
Savings Acct.	$8,500.00
Checking Acct.	309.88

The original investment in the Butler notes was $2,000 on which only $1,190.12 was realized when the property was sold—a loss of $809.88 on the investment.

ALLOTMENTS

	Allotted	*Receipts*	*Expended*
Secretary's Office	$ 499.85*		$ 499.24
Treasurer's Office	225.00		202.12
Journal	3,100.00	+$535.49=$3,635.49	3,548.21†
Meetings Committee	350.00		306.70
Custodian & Subs. Mgr.	120.00		37.79‡
Membership Committee	10.00		—
Executive Committee	10.00		—
Journal Clerical Asst.	240.00	=$300.00	266.35
Journal Misc. Expense	60.00		
Directory	350.00		341.35

* Original allotment of $450 plus additional allotment of $49.85.
† This includes bill for December JOURNAL printing and estimated amount of December reprints.
‡ This amount does not include a bill for $1.90 outstanding from 1941 expenses.

Report of the Committee of Auditors

The Committee of Auditors, P. A. SMITH (chairman), H. G. AVERS, and C. H. SWICK, presented the following report:

The accounts of the Treasurer of the Washington Academy of Sciences for the year 1941 were examined by your committee on January 13, 1942. The neat and orderly manner in which the records were found is a matter for especial commendation. All receipts and disbursements in his report were verified against all vouchers and balance sheets from the bank. Vouchers are properly approved and the report is correct. Securities listed in the Treasurer's report were inspected on January 13, 1942, and the statement of assets of the Academy is correct.

On motion, the reports of the Treasurer and the Committee of Auditors were accepted.

Report of the Archivist

The Archivist, N. R. SMITH, presented the following report:

Since this is the first formal report of the Archivist, the larger items now in the Archives are listed: A complete bound set of the Proceedings of the Academy from 1899 to 1911, a complete bound set of the JOURNAL from 1911 to date, both in good condition.

Of the Directories published by the Academy since 1899 only two editions are missing, viz: 1901 and 1912. Prior to the publication of the Academy Directory, the Joint Commission of Scientific Societies published directories each year beginning with 1889 and ending with 1898. Of these ten editions, the following six are missing: 1889, 1890, 1891, 1893, 1894, and 1896. Although strictly speaking these may not belong to the Academy Archives, it is felt that they should be included and some effort be made to complete the set. Therefore, if anyone has copies of the missing editions mentioned above, the Archivist will be very glad to have them.

One mysterious small package has remained sealed since March 23, 1898. The label says, "This package containing the ballots by which the nucleus of the Washington Academy of Sciences was selected as presented by the Joint Commission of Scientific Societies to the Academy with the request that it be not opened within 20 years. Its official history appears on pages 41, 45, 46, and 55 of 'Record Joint Commission Vol. II, 1897.' Sealed and delivered March 23rd, 1898. Marcus Baker, Secretary, Joint Commission."

The main bulk of the material turned over

to the Archivist consists of old records of the secretaries and the treasurers together with nomination blanks and correspondence. Up to 1912, all correspondence was copied into letter press books which are in the Archives. Since then the correspondence has been filed in various ways, each officer having his own likes in the matter. This dusty material is being sorted as time permits.

On motion, the report of the Archivist was accepted.

Report of the Board of Editors

The Board of Editors, J. H. KEMPTON, R. J. SEEGER, and G. A. COOPER, submitted the following report for 1941:

Volume 31 of the JOURNAL for the calendar year 1941 consisted of 12 issues totaling 528 pages. It contained 62 original articles of which 36 were by members of the Academy and 26 were communicated. Space was distributed as follows:

Natural Sciences	319½ pages	60 per cent
Physical Sciences	151¼ pages	29 per cent
Proceedings	40½ pages	8 per cent
Obituaries	10¾ pages	2 per cent
Index	6¾ pages	1 per cent

There was appropriated by the Board of Managers to the Editors for printing, illustrating, reprints, and mailing the JOURNAL $3,100; for clerical assistance $240; for postage and incidentals $60—a total of $3,400. Of this sum there was expended for clerical assistance $240; for postage and incidentals $28.93; and for printing, illustrating, reprints, and mailing $3,545.54. The total cost of issuing Volume 31 was, therefore, $3,814.47. Of this amount authors, institutions, or societies paid $604.48 to cover the cost of excess illustrations, printing costs, and reprints, leaving $3,209.99 to be charged to the Editors' budget of $3,400. There is, therefore, an unexpended balance of $190.01.

At the close of the year the Editors had on hand and accepted for publication 13 manuscripts totaling 259 typewritten pages and 18 illustrations.

On motion, the report of the Board of Editors was accepted.

Report of the Custodian and Subscription Manager of Publications

The Custodian and Subscription Manager of Publications, W. W. DIEHL, presented the following report for 1941:

The stocks of Academy publications available for sale as revealed by the appended inventory are more complete than during the previous year. At the beginning of the year 1941 by special action of the Board the Custodian was authorized to augment the then depleted supply of certain volumes of the JOURNAL sufficient to secure a reserve available to purchasers of unbroken sets, particularly in the interest of prospective institution subscribers. This was to be accomplished by means of a fund supplied by the sale of complete sets. Since this fund was available early in the year it has been possible to purchase advantageously most of the numbers needed; and at the present time there are lacking but six numbers in older volumes and three recent volumes, all in one set, to complete the authorized reserve: eight sets Vols. 1–30, six sets Vols. 11–30, and 13 sets Vols. 16–30. To this reserve there have been added two additional sets, Vols. 1–29, released for sale on order of the Board by the Secretary of the Academy and the Editor of the JOURNAL. That this policy of assembling reserve sets has been justified is attested by the fact that although three of these reserve sets were sold during the year to institutions, we are still in a position to meet any reasonable demand in the near future.

Contrasted with the favorable aspects of stocks at hand the subscription list is less satisfactory.

Nonmember subscribers in the United States..... 89

Nonmember subscribers in foreign countries..... 40

Geological Society of Washington..... 15

Because conditions have not warranted the expenditures anticipated the amount actually used, chiefly in maintaining correspondence, has been but $37.79 of the budget allowance, leaving an unexpended balance of $82.21.

On motion, the report of the Custodian and Subscription Manager of Publications was accepted.

Report of the Tellers

The Committee of Tellers, L. B. TUCKERMAN (chairman), and R. W. BROWN, presented their report as follows on the annual election of officers for 1942 and on the amendments to the bylaws:

A total of 237 ballot envelopes were delivered to the Committee by the Secretary. Of these, 2 bore no signature and 1 bore the signature of a member in arrears.

In the remaining 234 envelopes there were found 184 ballots on the Amendments to the Constitution and 234 ballots for Officers and Manager of the Academy.

The count of the ballots on the Amendments showed

For the Amendments	182
Against the Amendments	1
Not voting	1

The count of the ballots on Officers of the Academy showed

For President, HARVEY L. CURTIS	222
For Secretary, FREDERICK D. ROSSINI	221
For Treasurer, HOWARD S. RAPPLEYE	221

Examination of the preferential ballot for Managers by the Hare system showed 4 unmarked ballots and 30 ballots which were invalid because marked with crosses from which no first choice could be determined, leaving 200 valid ballots. The Droop quota was therefore $(200+1)/(2+1)=67$. The count of the ballots showed the necessary quotas for ROBERT F. GRIGGS and FRANK C. KRACEK, after transfer of votes from the fourth place.

Nominations for Vice-Presidents

For the respective affiliated societies, the Secretary presented the following nominations for Vice-Presidents of the Academy for 1942:

Philosophical Society of Washington: WILLIAM G. BROMBACHER
Biological Society of Washington: ERNEST P. WALKER
Chemical Society of Washington: HERBERT L. HALLER
Entomological Society of Washington: AUSTIN H. CLARK
National Geographic Society: ALEXANDER WETMORE
Geological Society of Washington: JOHN B. REESIDE, JR.
Medical Society of the District of Columbia: FRED O. COE
Columbia Historical Society: ALLEN C. CLARK
Botanical Society of Washington: JAMES E. MCMURTREY, JR.
Archaeological Society of Washington: ALEŠ HRDLIČKA
Washington Section of the Society of American Foresters: WILLIAM A. DAYTON
Washington Society of Engineers: PAUL C. WHITNEY
Washington Section of the American Institute of Electrical Engineers: FRANCIS B. SILSBEE
Washington Section of the American Society of Mechanical Engineers: WALTER RAMBERG
Helminthological Society of Washington: EMMETT W. PRICE
Washington Branch of the Society of American Bacteriologists: LELAND W. PARR
Washington Post of the Society of American Military Engineers: CLEMENT L. GARNER
Washington Section of the Institute of Radio Engineers: HERBERT GROVE DORSEY
Washington Section of the American Society of Civil Engineers: HERMAN STABLER

On motion, the Secretary was instructed to cast a unanimous ballot for these Vice-Presidents.

Awards for Scientific Achievement for 1941

President CLARK announced the recipients of the Academy's Awards for Scientific Achievement for 1941, as follows:

For the Biological Sciences, to—

G. ARTHUR COOPER, U. S. National Museum, *in recognition of his distinguished service in invertebrate paleontology, notably for discovery of anatomical structures hitherto unknown.*

For the Engineering Sciences, to—

THEODORE R. GILLILAND, National Bureau of Standards, *in recognition of his distinguished service in originating automatic ionosphere recordings for continuously variable radio frequencies.*

For the Physical Sciences, to—

STERLING B. HENDRICKS, U. S. Bureau of Plant Industry, *in recognition of his distinguished service in determining the constitution of micaceous and other complex minerals.*

As business from the floor, remarks were made by ATHERTON SEIDELL and W. J. HUMPHREYS. The former suggested two ways in which the Academy could increase its service to science, one by publishing in the JOURNAL lists of the publications issued by the Govern-

ment in scientific fields and the other by maintaining in its library a complete file of Government publications. The latter suggested first, that the Archivist could advertise in the JOURNAL the need for certain old Directories in order to complete the files, and second, that a committee should be appointed to examine the sealed package of ballots (see report of the Archivist), which was requested by the Joint Commission of the Scientific Societies not to be opened within 20 years of March 23, 1898.

President CLARK appointed Past Presidents ALEXANDER WETMORE and T. WAYLAND VAUGHAN to escort the new President, HARVEY L. CURTIS, to the chair. After a short address, President CURTIS declared the meeting adjourned at 10:20 P.M., for a social hour.

FREDERICK D. ROSSINI, *Secretary.*

ANTHROPOLOGICAL SOCIETY

The Anthropological Society of Washington at its annual meeting held January 20, 1942, elected the following officers: President, GEORGE S. DUNCAN; Vice-President, JULIAN H. STEWARD; Secretary, REGINA FLANNERY; Treasurer, T. DALE STEWART; Members of the Board of Managers, WM. N. FENTON, H. W. KRIEGER, R. UNDERHILL, J. E. WECKLER, and WALDO R. WEDEL. A report of the membership and activities of the Society since the last annual meeting follows:

Life members	2
Active members	43
Associate members	11
Total	56

The members elected during the year were: Sister BERNARD COLEMAN, Mrs. MARGARET D. FOSTER, S. L. PERCHICK, and J. E. WECKLER, all active members.

Through death the Society lost one associate member, DAVID IVES BUSHNELL, JR. The following resolution was adopted:

Whereas: David I. Bushnell, Jr., a member of this Society for more than 30 years, passed from this life on June 4, 1941, and

Whereas: Mr. Bushnell was closely associated with the members of this Society during the greater part of that time, was a collaborator in the work of the Bureau of American Ethnology and the Smithsonian Institution, and the author of numerous valuable papers in ethnology and archeology, which appeared in the publications of the Bureau and the Institution, and in the *American Anthropologist*, the organ of the Anthropological Society,

Be it resolved: That the Anthropological Society of Washington hereby expresses its high appreciation of Mr. Bushnell's work, its deep sense of the loss suffered by our science in his removal from among us, and on the part of our membership a profound feeling of personal bereavement.

The Treasurer's report is as follows:

Funds invested in Perpetual Building Association (with interest to date)		$1636.74
21 shares Washington Sanitary Improvement Co. (par value $10 per share)		210.00
2 shares Washington Sanitary Housing Co. (par value $100 per share)		200.00
U. S. Savings Bond, Series G (on order)		500.00
Cash in bank		188.20
		$2734.94
Bills outstanding:		
To American Anthropological Association	$55.00	55.00
		$2679.94
Total as of January 18, 1941		2529.81
Increase		$ 150.13

It was decided to set aside a portion of the annual increase each year as a reserve for publication. When funds are adequate these funds may be appropriated to underwrite the publication of anthropological papers to be known as "Contributions from the Anthropological Society of Washington" and published as Memoirs of the AAA. Special attention will be given to studies of the history and archeology of the early inhabitants of the District of Columbia and vicinity, since no other society assumes responsibility for such studies.

Papers presented before the regular meetings of the Society were as follows:

January 21, 1941, 697th meeting, WALDO R. WEDEL, *Archeology and environment in the Great Plains.*

February 18, 1941, 698th meeting, T. DALE STEWART, *Archeological investigations at the historic Indian village of Patawomeke in Stafford County, Va.*

March 18, 1941, 699th meeting, held jointly with the D. C. Chapter of the American Sociological Society, JOHN PROVINSE, *Cooperative effort in sociology and anthropology.*

April 15, 1941, 700th meeting, INA C. BROWN, *Social structure and the status of the American Negro.*

October 21, 1941, 701st meeting, ROBERT H. LOWIE, *Nimuendajú's findings among the Botocudo.*

November 27, 1941, 702d meeting, held jointly with the Washington Academy of Sciences, MATTHEW W. STIRLING, *Treasure trove of Mexican archeology.*

December 16, 1941, 703d meeting, WALTER W. TAYLOR, *Cave exploration in northern Mexico.*

REGINA FLANNERY, *Secretary.*

CHEMICAL SOCIETY

535TH MEETING

The 535th meeting was held in Corcoran Hall, George Washington University, on Thursday, October 9, 1941, at 8:15 P.M., with Dr. H. L. HALLER as Chairman. After routine business of the Society, 14 papers were presented by 24 authors in four sections as follows:

Biochemistry, DR. H. M. DYER, *presiding*

Plant gonadotropes. J. T. BRADBURY and E. T. GOMEZ.

A comparative study of methods for the determination of vitamin C. JOSEPH H. ROE and JAMES M. HALL.

Co-carcinogenesis. M. J. SHEAR and JOSEPH LEITER.

A crystalline protein fragment from a wheat lipoprotein. A. K. BALLS, W. S. HALE, and T. H. HARRIS.

Organic chemistry, DR. E. E. FLECK, *presiding*

The influence of structure on the hydrolysis of glycosides by the enzymes of almond emulsin. WILLIAM WARD PIGMAN and NELSON K. RICHTMYER.

Centers of asymmetry in the chlorophyll molecule. LEWIS J. SARGENT.

Problems confronting the pharmaceutical chemist. F. H. WILEY.

Physical chemistry, DR. F. D. ROSSINI, *presiding*

Transition behavior of some of the sulphide-type compounds of silver. FRANK C. KRACEK.

Mechanism of the decomposition of ammonia. STEPHEN BRUNAUER, KATHARINE S. LOVE, and R. G. KEENAN.

Photochemical reduction of methylene blue in fats and oils. GEORGE R. GREENBANK and GEORGE E. HOLM.

Some metallic ion complexes. J. E. DRALEY.

Inorganic and analytical chemistry, DR. P. S. ROLLER, *presiding*

Preparing refractory materials for analysis by treatment with HCl at elevated temperatures. EDW. WICHERS and W. G. SCHLECHT.

Determination of free silica in the presence of silicate by hydrofluosilicic acid. F. H. GOLDMAN.

Some aspects of the coordination chemistry of the platinum group. R. GILCHRIST.

536TH MEETING

The 536th meeting was held in Room 108 of the Chemistry Building, Georgetown University, on Thursday, October 30, 1941, at 8:15 P.M., with H. L. HALLER as Chairman. The speaker of the evening was Dr. B. H. NICOLET, of the Bureau of Dairy Industry, Beltsville, Md., who spoke on the subject *The use of periodic acid on the study of proteins.*

537TH MEETING

The 537th meeting was held in the Auditorium of The Catholic University of America, on Thursday, November 13, 1941, at 8:15 P.M., with H. L. HALLER as Chairman. Election of officers for the Society for 1942 took place, the results being as follows:

President: NORMAN BEKKEDAHL.
Secretary: E. R. SMITH.
Treasurer: M. M. HARING.
Councilors: N. L. DRAKE, W. D. COLLINS, H. L. HALLER, R. M. HANN, J. H. HIBBEN, F. O. RICE, F. D. ROSSINI, M. X. SULLIVAN, E. WICHERS.
Managers: J. J. FAHEY, R. GILCHRIST, S. B. HENDRICKS, C. HEURICH, D. B. JONES, N. K. RICHTMYER.

The speaker of the evening was Prof. ALEXANDER SILVERMAN, head of the Department of Chemistry, University of Pittsburgh, who spoke on the subject *Glass: Today and tomorrow.*

538TH MEETING

The 538th meeting was held in the Auditorium of the Cosmos Club, on Thursday, December 11, 1941, at 8:15 P.M., with H. L. HALLER as Chairman. The speaker of the evening was Prof. HENRY EYRING, Chemistry Department, Princeton University, who spoke on the subject *A theory of some rate and thermodynamic properties of surfaces, including boundary lubrication.*

NORMAN BEKKEDAHL, *Secretary.*